Appendix A

Richard Wyatt, MD

Office of Intramural Research

National Institutes of Health

I appreciate the opportunity to be here this afternoon. My comments are mainly in the context of the NIH intramural program.

I'd like to quote Lewis Thomas, from a foreword he wrote to a book by DeWitt Stetten, who was the Deputy Director for Intramural Research at the National Institutes of Health (NIH). Thomas wrote: "One aspect of the intramural program deserves special mention and emphasis: It is as a training ground for young investigators who have come to Bethesda for their postdoctoral education and research that the Institution has achieved its most singular influence on the progress of American science." Lewis then talked about the two to three years of apprenticeship at the NIH and the subsequent deployment of the postdoctoral trainees to the universities to become the country's leaders of academic science. That was the right thing to do then. So the question is, "What is the right thing to do now?"

In thinking this through, I'd like to address three issues: first, paying attention to capturing the interest of potential investigators very early on in their careers; second, offering didactic training and proper mentoring to them as they move through this training experience; and, third working in partnership with public and private sectors.

We in the intramural program believe that we have a major role to play in training tomorrow's investigators. This involves recruiting the best and the brightest talent into research careers. We have training programs at all levels, beginning with the high school and moving on up. We have a new program called "the undergraduate scholarship program" for disadvantaged individuals, which is well underway and is providing a wonderful opportunity now for a group of undergraduate students.

I will limit my comments, though, to the "clinical researcher." I believe that the intramural program is poised to be a training ground for just that population. There are historical features and underpinnings, of course, which have brought us to this point.

To go back to 1982, very briefly, there was a summer program at the time specifically designed for medical and dental students. That program would accommodate 80 to 100 medical and dental students each summer. We have had, as of now, 1,625 students participating in that training experience. About 57, or 3.5 percent, of those have been dental students. This number, however, is only a fraction of a growing summer program at the NIH. We have probably on the order of a thousand students here each summer now learning to do research in virtually all fields.

In 1985, NIH Director James Wyngaarden, and the Howard Hughes Medical Institute (HHMI) President, Donald Fredrickson, felt that a training program longer than just a summer would be important to capture the interest of such students and to give them valid research experience. At that point, the HHMI-NIH Research Scholars Program was created. The HHMI program, as we call it, was specifically intended to provide training in basic laboratory research, despite the fact that this was a program designed for second-year medical students. They all came into NIH laboratories at the time. To date there have been 567 students who have participated in the program since its beginning. Of those students, 110 enjoyed it so much that they stayed for a second year. There have been no third-year students to date, although few have departed from the medical track, and done a Ph.D. before returning to medical school.

Of those, over half are in academic positions. This is not a controlled study, but it is hard to say that this program has not been a success. I should just mention parenthetically the program has been open to dental students. Since 1994, there have been few applicants, and one student who participated in the program.

In 1995, NIH Director Harold Varmus established the NIH clinical research panel to address the question: "Who is going to do clinical research?" Dr. David Nathan chaired the panel and it didn't take them very long to come up with the idea of creating a clinical research counterpart to the HHMI program. They noted that it was very important to stimulate interests in research early in the careers of the students, and early in their training experience. So the NIH created the Clinical Research Training Program. It resembles in many ways the Howard Hughes Medical Institute Research Scholars Program. To date there have been 38 students who have participated or are about to participate in the program. There have already been two dental students, one from UCLA and one from Tufts University. The program differs from the HHMI program in that it is designed for third-year students -those who have completed their clinical rotations. As with the HHMI program, this is a public/private venture. The Pfizer Corporation, through a generous grant to the Foundation for the NIH, has supported the clinical research training program for two years.

Another theme that I'd like to touch on is the development of didactic training for clinical researchers and patient-oriented researchers as they gather the complex information that is needed to do research in the next century.

The NIH Clinical Research Panel noted a lack of formal didactic training among clinical researchers and so the clinical research-training program has a didactic component. We also have added a new NIH grant mechanism -- so called "K30" or the "curriculum development award." Approximately $7 million has been awarded to 35 institutions to date.

Students in our clinical research-training program participate at the NIH in a formal course that has been devised by the NIH Clinical Center. This is the "Introduction to the Principles and Practice of Clinical Research." This particular course was first established in1995. It consists of four modules of didactic training over the course of several months. It's roughly 48 hours of classroom-type work seminars and discussion groups.

There are other opportunities. Let me just mention briefly that NIH is involved in an intensive learning experience in collaboration with Duke University. This is an experiment in long distance learning that leads to a Master's Degree in Clinical Research. Fourteen students took the course the first year it was offered. This year there may be as many as 22 students involved in that master's degree program.

We have also focused recently on the topic of mentoring. This past year we published a booklet called, "Training and Mentoring in the NIH Intramural Research Program." This booklet is made available to all students, postdoctoral and senior scientists at the NIH.

We believe it is important, as a part of the training experience to describe to students and postdoctoral scientists what is expected and, in turn, to provide the mentors with the same information. Then everyone is looking at the training experience in the same way.

These concepts that I've reviewed are not innovative, but I believe that, if they are followed, they should lead to the development of a cadre of enthusiastic, well trained, highly monitored investigators for the next century. Several of these programs represent the kind of public/private partnerships that are possible as well as the government/university partnerships.

One closing comment: I am reminded of what one of my early mentors in the laboratory told me. He said, "Richard, you must be ready to change directions in research at a moment's notice."

With the kind of training and mentoring that I have described, these people will be ready to meet that challenge as we move into the next century.

Bettie J. Graham, PhD[1]

Division of Extramural Programs

National Human Genome Research Institute

It is a pleasure for me to be here this afternoon to share with you some of our research career development programs that we have developed in order to make the Human Genome Project a success.

The product of the Human Genome Project will be a lot of data. In order for this to be useful information, people will have to be able to use it in a manner that lets small laboratories have access to it. To accomplish this, we have a palette of career development programs that we developed by talking to the people in the community. Before I tell you about those programs, however, I would like to tell you about our first experience once the genome program was organized.

We assumed that the traditional institutional training grants and the individual fellowships would meet our research training needs. The architects of the project soon realized that we needed people with expertise in engineering, computer sciences, physics, mathematics, and chemistry. These are specialists who traditionally don't think of biology as an area for them to consider.

Moreover, at about this time that the program was getting started, industry was also getting heavily into bioinformatics and genomics. So many people were being recruited into industry at salaries that were three and four times what they could get on a National Research Service Award grant, it was clear that we had to do something different.

We started out with the K01 award, which is the individual Mentored Research Science Development award at a salary of $50,000. Our first round went very well. Then, about a year later, we got a call from a couple of the mentors saying that their people were leaving because industry had a greater pull on them at a greater salary. So we raised the cap to $75,000, but clearly that was not enough. So we decided, rather than chase the salary cap, that we would make a decision to go with the NIH salary cap which is currently about $126,000.

This is just some of the angst we were dealing with when we were trying to recruit the kinds of people that we really needed in addition to the geneticists and the molecular biologists.

Two years ago I interviewed about 20 computer scientists, mathematicians, physicists, and engineers in academia to find out what we could do to attract the kind of people that we really wanted to become involved in genomic research. About half were genome scientists and the other half were working in other areas of computer science or engineering, chemistry, and mathematics. The group ended up with a list of 14 recommendations that I categorized into five categories. These were:

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[1] Formal statement is available from the NIDCR Division of Extramural Research.

sciences and this area of research would be exploding in the future. They were not really poised to take advantage of this.

They talked about the situation in which a department chairman in the biological sciences would have an opening. Instead of hiring someone in engineering or computer science, they would much prefer to hire somebody in biology. If you were really trying to move the department into interdisciplinary research, this situation proved very difficult.

Another recommendation this group made was to encourage private and philanthropic organizations to support endowed chairs -- in other words, to assist the universities in building infrastructure. They felt that it was not always necessary to create a new department. What was really important was to have a new concept of how interdisciplinary research could be done.

I think probably the NIH exemplifies that approach more than a university. In the intramural program, there is communication among all of the groups and there isn't this strict division along departments of scientific disciplines.

Some of the people I talked with had training programs. One of the things that they identified as a need was "curriculum development". We are talking about a new way of doing science. Yet, training directors really don't have the time to develop rigorous courses of training that would give the students the skills that they need to do "genomics."

In terms of career development, they had a series of recommendations. One was to develop an institutional K01. They recommended that we increase the number of K01 awards that we now make, increase the number of training grants, encourage departments of mathematics and biology to be partners in this, and to address the stipend levels.

There was nothing we could do about the stipend levels, because those are established by Federal regulations. So we hoped our program directors would consider it helpful to them if we increased the institutional allowance. We did this for the first time during the most recent round of reviews. We hope this will provide the training directors with more flexibility in developing an interdisciplinary training program that will attract the right type of students.

"Research" was another area mentioned by the group I interviewed. They expressed concerns about how research projects are reviewed by the NIH. These projects represent non-hypothesis-driven science. Members of the group felt that it was possible that the reviewers don't understand the need for this type of science. As I understand it, the Center for Scientific Review at NIH is currently addressing this concern.

Traditionally, we fund grants for three years, especially if they are technology grants. We feel that science is moving rapidly and we don't want to be locked into five years of project support. Three years give us and the applicant an opportunity to respond to rapid changes in technology. Members of the group felt that three years was not enough for the type of research that they were doing. This is a point that we have not yet addressed.

We need to increase the dialogue with the research community so that they are aware of the research opportunities that are available in this area. The group that I interviewed suggested that we convene leaders in industry and academia to discuss common interests and needs in research and in training.

As a result of their many suggestions we developed several new programs that are outlined in the table below. There are still many challenges ahead. For example, we need to learn more about how to make biology attractive to physicists, chemists, mathematicians, computer scientists, and engineers. We need to have departments and institutions that are more open to hiring people in nontraditional areas. We need to ensure that the current curriculum for graduate students is such that they will be able to use the information that is being generated by the Human Genome Program.

It doesn't help to find out the complete sequence of the human genome if individuals working in small laboratories cannot analyze and use that information in their own research. These are just some of the things that we still need to do in order to ensure that we have a properly trained group of scientists for the next century.

NATIONAL HUMAN GENOME RESEARCH INSTITUTE
RESEARCH AND CAREER DEVELOPMENT PROGRAMS

Mechanism	**Purposes**	**Eligibility Requirements**	**Allowable Costs**
K01 Individual Mentored Research Scientist Development Award	To prepare non-biologists to become independent genome investigators.	Must have PhD or equivalent in non-biology science; less then two years experience in biology; open to scientists at all career levels.	Salary up to NIH cap; $20K for research development support; tuition; 8% IC. 3-5 years of support may be requested. Award is non-renewable.
K12 Institutional Mentored Research Scientist Development Award	To prepare non-biologists to become independent genome investigators; the application is submitted by the institution, rather than by an individual and up to 3 positions can be requested.	The institution must have a well-established research program in genomics research or genomic approaches to genetics or functional/analyses. The nominees are selected by the institution and must meet the same requirements as those for the K01 program.	Same as for K01 awards. Up to 5 years may be requested for the grant; appointees may be appointed for 3-5 years.
K22 Genome Scholar and Faculty Transition Award	To enable promising new genome researchers establish an independent research program in genomics research and analysis and to secure a tenure-track faculty positions. Individuals can apply for genome scholar postdoc and faculty	Must have no more than 5 years PD experience for combined award and no more than 6 years PD experience for Faculty Transition Award; be a PD at the time of applying; be engaged in fundamental or applied genomics research and analysis or tech. dev. research as it applies to	Up to $150K(DC) annually for the genome scholar award for up to two years and up to $250K(DC) annually for faculty transition award for up to four years. Total number of years is 5 for both awards and is 4 years for the Faculty Transition Award. Award is non-

	transition award or for the faculty transition award only.	genomics; not have had prior independent grant support. Faculty Transition Award is tenable only at institutions different from where PD or Genome Scholarship pursued.	renewable.
K07 Curriculum Development Award in Genomic Research and Analysis	To support the development of courses and curricula designed to train interdisciplinary scientists who wish to combine knowledge of genomics and genetics research with expertise in computer science, math, chem, physics, eng or a closely related science.	PI must be engaged in genomics and/or genetics research in one of the non-biological fields and must have a collaborator who will contribute to the interdisciplinary nature of the courses or curricula	Percent effort of PI must be consistent with the proposed project; up to $20K for collaborators, equipment, etc. Award is non-renewable.
T15 Short Courses in Genomic Analysis and Interpretation and ELSI Related Research	To support short, advanced level courses that will enhance the skills of US scientists and scholars who are interested in pursuing laboratory research that utilizes data and materials generated by the HGP or scholarly research relevant to the ELSI goals of the HGP.	Applications may be submitted by individuals who have developed technologies and information that should be disseminated to the larger US scientific community for use in genomics/ genetics and ELSI research projects.	PIs may request release time to prepare and teach courses as well as costs to cover speakers, equipment, and a limited number of scholarships. Applicants may request multi-year funding.
T32 NRSA Institutional Training Grant in Genomic Analysis and Interpretation	To train scientists who will have the multi-disciplinary skills that will enable them to engage in research to accomplish the long-term objectives of the HGP and to take full advantage of the resulting data and	US domestic academic institutions may apply. The institution must have a well-established research program in genomics research or genomic approaches to genetics or functional/analyses. Pre-doctoral and postdoctoral students may be	Stipends; reasonable administrative costs; tuition and an institutional allowance based on the number of students and postdoctoral fellows. Up to 5 years of support may be requested for training grant.

	resources to solve biomedical problems.	appointed to the program.	
F32/F33 NRSA Individual Postdoctoral Fellowship	To provide additional training for individuals who wish to pursue research relevant to the short- and long-term goals of the HGP.	A PhD or the equivalent in the area of interest.	Stipend, institutional allowance and tuition, if appropriate. Up to 3 years of support may be requested.
F31 NRSA Individual Pre-doctoral Fellowship Award	To increase the number of minority scientists and scientists with disabilities conducting biomedical research.	Must be accepted into an accredited graduate school at the time of application submission; must meet the criteria for a minority student or a student with a disability.	Stipend, institutional allowance and tuition. Up to 5 years of support may be requested.
Administrative Supplements	To provide a short- or long-term research experience for students/faculty with disabilities and the number of minority students/ faculty order to increase their participation in biomedical research.	Must meet the criteria for a minority student/faculty/institution or a student with a disability.	Funds may be requested to spend a semester or several years working in the laboratory of an NIH-funded investigator. Students/faculty may also request funds to attend genome-related scientific meetings.

All Career Development and Training Programs are limited to U.S. Citizens or Permanent Residents of the U.S.

Website address: http://www.nhgri.nih.gov/grant_info/funding/training

Clifton Poodry, PhD

Division of Minority Opportunities in Research

National Institute of General Medical Sciences

I appreciate the opportunity to share some thoughts from those of us at the National Institute of General Medical Sciences (NIGMS). The Institute is a basic research institute with no particular disease to follow, but it is also very heavily invested in training. Certainly, our goal is to support high-quality, basic research, but it is also to provide opportunities for long-term and/or high-risk research -- that is, those kinds of studies that could provide opportunities for the future. This requires a strong biomedical research workforce and one that reflects the composition of the U.S. population.

In addition to the research portfolio, then, the Institute has a significant portfolio of training. The objective is to establish programs that result in a cadre of highly qualified researchers, to tap the talents of all members of the society. This requires that we stimulate and encourage Ph.D.-

granting institutions to establish or improve programs for identifying, recruiting, retaining, and training talented individuals, including women and minorities.

One of the divisions in the National Institute of General Medical Sciences is the Minority Opportunities in Research Division. The division has as its mission to increase the participation of under-represented minorities in biomedical research.

When I came to this very interesting job about five years ago, there was a wonderful challenge. The programs had come under fire for being both ineffective and, in some cases, resembling entitlement.

One of the things that we did was to establish a guiding principle: our programs would be developmental rather than merely sustaining. For a program to be developmental, things have to improve. We are committed to the long-term, stable support contingent upon continual improvement. We wanted to provide the kind of resources that would enable developing institutions, developing departments, and developing individuals with the tools they need to succeed.

So, we changed our programs considerably. Our desired outcomes, then, are competitive minority researchers. These are individuals entering research careers who will be competing for a range of research funding from NSF and from the various Institutes at NIH. We wanted students excited about research, but also well prepared to go into graduate programs. To accomplish this goal, we needed institutions committed to the development of minority students. The older paradigm was this: If we can get minority students into research laboratories to experience research, good things will happen. To develop the next generation of students, we wanted to support the most effective activities that motivate students. By that we mean that our programs will promote innovation in a competitive environment. We wanted to support activities that develop the potential of these students and to support them in their careers. So, we used a variety of fellowship and faculty development activities. We need to understand the effectiveness of efforts to ensure that programs were on track in pursuit of specific goals and objectives.

One of the things that we needed to understand was just where students are in the scheme of things. When you think about the career path of a student starting anywhere from K through 12, there are various things that we can do to catalyze the movement into a scientific career.

Where are some of the pinch points? Well, one of the difficulties is that for several populations simply graduating from high school is a challenge. For the Hispanic population, only 65% percent graduate from high school; for American Indians it is about 50 percent. Of those students graduating from high school, many of them are under-prepared and are not going to go on to strong college careers, much less post-baccalaureate careers. So, the reduction of eligible students at that first stage of career development is really enormous and yet we do not have programs to address the issue.

Where we do have programs to recruit students in college, we see a further reduction in percentages of Hispanic students, black students, compared to white students who complete their education. Furthermore, there is a two-fold difference in the graduation rate to the Ph.D. About 50 percent of majority students drop out before earning a doctorate. This dropout rate is 75 percent for minority students. If we could somehow increase the retention, we would double the numbers in just a single generation.

We believe that understanding the data is crucial to developing any kind of programming.

One of the hallmarks of our program, in addition to continual improvement, is that we believe that we need to engage more minds in solving the problem of under-representation. It is, in fact, the individuals at these institutions who solve the problems. You will find, however, that most minority programs have not relied on finding new partners or conferring with each other to solve the under-representation problem. In part this was due to the fact that government agencies prescribed the kind of activities these institutions should undertake. We wanted to engage more minds. What we did was to offer a great deal of flexibility. We asked for improvement. "You tell us what it is that you plan to do. What are your goals and objectives and how would you evaluate your progress?"

This is a different approach to evaluation. In the old model, programs would exist for a number of years and then some agency would evaluate the whole activity. We're asking our grantees to be a lot more like scientists: "You proposed specific objectives. You proposed a plan to get there. Therefore, you should know whether or not you've gotten there. You should be able to evaluate your own progress."

Our approach is more institution-centered, giving individuals, institutions, and scientific societies the opportunity to solve this very important problem. It is a challenge for us all to systematically analyze the problem and devise comprehensive plans to eliminate the barriers that lead to disparities in representation in biomedical research.

W. Paul Jennings, PhD

Graduate Research Traineeship Program

National Science Foundation

I find graduate education to be an exciting venture at this moment. The National Science Foundation (NSF) has tried to address the changes that are taking place by asking for a paradigm shift in graduate education. The focus is a bit more on education.

I would like to give you some information about a program that grows out of this paradigm shift. It is called the "Integrative Graduate Education and Research Training" Program or IGERT. It is a program that awards grants to institutions to provide graduate student traineeships. The program is designed for inter- or multidisciplinary training only. It is not designed to support training in a single discipline.

The rationale behind the design of IGERT is this: If we want to really change graduate education, we must ask the disciplines to work together. We are looking for and encouraging proposals that encourage graduate students in the following ways:

- Intellectual Depth
- Intellectual Breadth
- Professional Growth Experiences
- International Awareness and Cultural Tolerance
- Leadership and Teamwork Skills
- Communication Skills
- Career Awareness
- Ethics Awareness

What is going to happen to graduate education in 15 or 20 years? What do we need to think about as we prepare graduate students to work in the various sectors of society?

The globalization of American industry clearly will require individuals with greater international awareness. There is likely to be increased competition for graduate students and increased competition for jobs. It is also conceivable that a company will decide that increased competition for profit margins will require them to lay off entire divisions of workers. Therefore, we need to prepare students to get through that sort of situation should it occur. The US workforce is also likely to be quite mobile. People are no longer going to be able to stay in a company without moving abroad.

Graduate students will need a new type of resume. They are going to need a resume that talks about their breadth. They are going to need resumes that give them credit for learning a special skill or subject while being in another program. I suspect that we will see more education facilities developing in the industrial sector.

What about public sector employment? I think that there will be more employment opportunities for PhDs in the public sector. Of course, we have observed a decline in graduate enrollments in recent years. With changes in the racial and ethnic composition of American society, we need to encourage greater participation of women and minorities in science and engineering to meet future workforce needs and to ensure that no segment of the population is denied access to graduate education.

There will be increased pressure on the public sector to meet societal needs. As this occurs, there are going to be many opportunities to conduct interesting research. We may also see the emergence of a new sense of nationalism in the face of the “globalization”. This trend may also affect opportunities for PhDs in the public sector. Lastly, we may expect to see a further stratification in society between those who understand science and engineering and those who do not. This is a very serious concern.

With respect to opportunities in academic settings, there are a number of interesting developments that we can anticipate. One of the most significant problems is the role for faculty who enter multidisciplinary or interdisciplinary research. Institutions will need to provide leadership and the infrastructure to facilitate collaborations within and outside the institution. Some of the changes they will need to consider include the following:

- Revamp the rewards system
- More emphasis on diversity
- More emphasis on global interactions
- Realize the strong competition for graduate students
- Facilitate graduate students’ quest for education
- Address the information revolution
- Develop a tracking system

Faculty will also have to provide the leadership and flexibility for graduate students to attain their educational goals. They will need to provide real career advice and mentoring and prepare students for a diverse spectrum of careers.

Likewise, graduate students must prepare for a broad array of employment opportunities. They will have to globalize their thinking and strengthen their skills in several areas: Communication, Teamwork, and Leadership. Of course, graduate students, faculty, and institutions will all need to join the information revolution with enthusiasm.

Barbara Filner, PhD

Graduate Science Education Program

Howard Hughes Medical Institute

As many of you probably know, the Howard Hughes Medical Institute (HHMI) is technically a medical research organization. Our purpose is to conduct research, which we've been doing since 1953. Hughes investigators are employees of the institute. At present, there are more than 300 of them located at more than 70 institutions across the United States.

A grants program was created in 1987, and the trustees specifically asked that the grants program have a focus on education as a complement to the science program and to train the next generation of biomedical researchers.

This year, the budget of the grants program is $90 million. There is an undergraduate component and a pre-college education program. These are oriented towards strengthening science education and attracting students to careers in science. The pre-college program also aims to build a scientifically literate public.

Undergraduate awards go to colleges and universities, and the grants are used for such things as curriculum development, faculty development, and research opportunities for the undergraduates. Pre-college awards go to museums and biomedical research institutes for their outreach activities in the community, very often working with local schools.

I have been responsible for the graduate education program for the last 11 years or so. This year the graduate education program budget is $20 million. The program includes three fellowship awards. The first is the Predoctoral Fellows in Biological Sciences. This program provides five years of support for study towards the Ph.D. We make 80 to 90 awards a year, for a total of approximately 400 students each year.

We also provide Research Training Fellowships for Medical Students. This program was modeled on the NIH "Cloister Program" which was put into place a couple of years before it. The purpose of the award is to extend the experience beyond the bounds of NIH. We make 60 awards a year for medical students to take a year out and engage in research full-time at their own medical school or at another research institute if they choose. Both the Research Year Fellows and the Cloister Scholars are eligible for a continued support award at the end of their research year. This continuation award is essentially a two-year scholarship that helps these young scientists minimize their debt as they complete their medical studies.

Our third fellowship program is Postdoctoral Research Fellowship for Physicians. These three-year awards go to individuals who have completed two years of clinical training. We make 30 awards a year.

Since 1987, we have also awarded a series of grants for short courses at Cold Spring Harbor and Marine Biological Laboratory. These awards meet the need for cutting-edge training for the national and the international science communities.

HHMI focuses on basic biological processes and on disease mechanisms. We specifically do not support training in health services research, health promotion or health education. The science program is organized around five fields of biology. We were concerned that the students might feel too limited by just those five fields, so we interpret those fields broadly when we award fellowships. (See table below.)

There are a number of elements common to all of the fellowships. The first is that these are awards to *individuals*. These are not grants to institutions. Students are given an award to conduct the kind of research they think they'd like to do at an institution of their choosing. Medical students and postdoctoral applicants must propose a research plan and have a mentor who participates with them in preparing the application.

We give them flexibility. About one-third of the pre-doctoral applicants wind up going to a different institution than the one they put down in the application. Fellows are also given the flexibility to shift the emphasis of the research during the course of their fellowship. They are not limited to what they've laid out in the research plan. We think it is very important that, as they proceed with findings and as new technologies become available, they be able to go with the flow.

The HHMI fellowship is also portable. If a fellow needs to change mentors or change institutions, we require a formal request. Most of the time we approve that request. Our experience has been that the fellows go on to complete their training or their degree following a change in plans.

In all of these programs we require full-time engagement in research. Our feeling is that doing it part-time just doesn't do it for them. In all of the programs we pay a stipend and research or education or institutional allowances. We also set aside a sum for the fellow's benefit which they can use to buy computers, go to meetings, get journal subscriptions, buy books, and so on. The latter amount ranges from $2,200 to $5,000 annually, depending on the program.

Our postdoctoral fellows especially appreciate the fact we encourage fellowship institutions to allow them to take any equipment that they bought with the fellowship funds with them when they have a new appointment and they are starting up their own laboratories. If there is a balance remaining in either the research allowance or the institutional allowance, and with the agreement of the mentor and the institution, this also will be made available to them for their start-up costs.

able to track their careers. We have information on numbers of fellows who get Ph.D.'s, apply for and receive NIH post-doctoral support or NIH grants, and obtain appointment to medical school faculty, plus years of training in medical school, and years of training in post-M.D. clinical training. As I am sure you know, it takes a very long time to get trained. This is the 11th year of our program, and we are only beginning to get numbers that we think can be viewed as meaningful.

We also have always had progress reports. However, we recently implemented a web-based progress report system. We are asking former fellows to give us career updates so that will allow us to follow their careers. We are hoping that the progress reports and the career updates will give us a good sense of where the fellows are going, and allow us to keep our programs attuned to where they need to be.

ELIGIBLE FIELDS OF STUDY

BIOCHEMISTRY	BIOINFORMATICS*
BIOPHYSICS	BIOSTATISTICS*
CELL BIOLOGY	DEVELOPMENTAL BIOLOGY
EPIDEMIOLOGY	GENETICS
IMMUNOLOGY	MATHEMATICAL AND COMPUTATIONAL BIOLOGY*
MICROBIOLOGY	MOLECULAR BIOLOGY
NEUROSCIENCE	PHARMACOLOGY
PHYSIOLOGY	STRUCTURAL BIOLOGY
VIROLOGY	

* Field added in later years.

Timothy Ready, PhD

Division of Community and Minority Programs

Association of American Medical Colleges

I have worked with the Association of American Medical Colleges for 10 years. I am the director of “Project 3000 by 2000”. This campaign aims to increase the number of minority students entering medical schools in the United States. I also administer a grants program called the “Health Professions Partnership Initiative”. I am a medical anthropologist by training.

To me some of the most exciting research opportunities in the coming years have to do with some of the most pressing health problems facing our Nation. We have the opportunity, for example, of engaging our institutions in the DHHS Initiative on Racial and Ethnic Disparities in Health Status. From my vantage point as a medical anthropologist and as someone who has worked in diversity programs for a number of years, the issue of “access” in health care has the potential to be a very productive line of research. Research in this area explores the interaction of social and cultural forces and health status.

The Surgeon General, Dr. David Satcher, has laid out six areas of health status disparity:

1. Infant mortality
2. Cancer screening and management
3. Cardiovascular diseases
4. Diabetes
5. HIV/AIDS
6. Immunizations

place in November. This Summit will involve the AAMC, AMA, and other stakeholders from the health care system with an interest in clinical research. The Wake Forest School of Medicine is co-sponsoring the meeting.

Parallel to that is an AAMC Task Force on Clinical Research. The Task Force is exploring how AAMC member organizations can strengthen their capacity to support clinical research programs given the current scientific, health care delivery, and financial environment. One question being explored asks, "What kind of incentives do students need to engage in research?"

I would like to talk a little about Project 3000 by 2000. This is a campaign whose focus is to increase the number of minority medical students. We receive very generous support from the National Institutes of Health for the project through the Science Education Partnership Awards program.

The work that needs to be done is not unique to medicine. There are problems of increasing diversity in all of the health sciences. These problems are common to dental education. They are common to medical education. They are common to all sorts of health professions. There is an over-arching two-pronged issue here. One of them has to do with "career exposure" and "motivation". The tougher issue has to do with "academics" and "academic preparation".

We believe that it is very important to rely on research to inform our efforts to develop initiatives. Research is involved in any kind of sound strategic planning. To increase the diversity of the health sciences workforce, it is our strong belief that we need to look at all relevant research. We have looked at data, for example, from the National Assessment of Educational Progress describing the science skills of seventeen-year-olds. We see an extraordinarily small number of Black and Latino students who are prepared to go on to do college-level science work. We think it is very important to work at that level to bring about change.

The Health Professions Partnership Initiative is predicated on the idea that there is a common foundation of skills that is needed whether one ultimately enters clinical practice or research in the health sciences. The Health Professions Partnership Initiative funds 16 partnerships around the country. We anticipate funding about 10 more partnerships in the near future. Half of those will probably be earmarked for schools and programs in public health.

So we expect to have 26 sites around the country where health professions schools are working in partnership with undergraduate colleges, school systems and community-based organizations to increase the diversity of the health workforce.

The first thing that these partnerships are supposed to do is to conduct research locally. We want them to look at the assets and the particular pool of students with which they will be working and figure out what it is going to take to get the outcomes they would like. They look at some very specific interim outcome goals for each stage of the pipeline.

Project 3000 by 2000 is going to be winding down as we approach the year 2000 and will be succeeded by other activities. One likely scenario is that there will be a new campaign that focuses on minority health research and aims to increase the number of minority researchers. Such an effort would represent a more integrated focus that would address segments of the population that have not benefited from the wonderful advances in basic science. What kind of translational research can be done? What kind of health services research can be done? These are the kinds of questions that could be asked in the context of Surgeon General Satcher's minority health initiative.

Richard Valachovic, DMD[2]

Executive Director

American Association of Dental Schools

I would like to depart from my written comments to address some of the issues raised during the Panel meeting. What I think we are doing is "envisioning the future". We are trying to identify the research opportunities for the future and the competencies that will be needed for that future.

This is a very complicated issue. If we ask, "What do we want the future to be like in 2010?" We can start now to make the changes that are needed to get there. Remember, it was the American Association of Dental Schools that in 1991 realized that dental education was at a crossroads. The AADS initiated discussions with the Institute of Medicine (IOM) to begin an independent study of our current status and our future needs. Fortunately, Dr. John Howe, who is a member of this Blue Ribbon Panel, was named chair of the IOM study. Their report was released in 1995 with 22 recommendations.

One of the key findings of the IOM report was that dental education and dental schools are a national resource for our country. They represent the one place where teaching, research and patient care occurs focusing on the dental and craniofacial complex.

[2] Formal statement is available from the NIDCR Division of Extramural Research.

Much discussion today has been about how NIDCR should fund the best scientists to do the best science no matter where that occurs. I would like to take exception to that rather simplistic view. Health sciences research has no value in reality unless it results in improved patient care. If it is just research for research purposes, then it is just the aggrandizement of a researcher or an institution. We need to move beyond just thinking about improved prevention or cure to the role that research plays in educating current students and residents, the impact on the practicing dentist and faculty and on the development of future scientists.

Dental schools don't feel an entitlement from NIDCR. But the investment in research must respect the importance of that research in affecting current and future practitioners and scientists within the dental school. Not all of the funding out of NIDCR has to go to dental schools. But the yield is going to be much higher when there is a respect for the dental school and the role that it plays in society. This is an important message that I would like to leave with you.

There has been much discussion today about what is going on at the predoctoral level in dental schools. Dental education remains significantly different than medical education. The end product of four years of dental predoctoral education is to have a practitioner who can go out and practice in the community independently. That isn't necessarily what the MD degree is meant to do. There are structured postdoctoral opportunities that are meant to be part of that preparation.

In October 1998, AADS convened a Leadership Summit with funding from NIDCR. The Summit was convened partly in response to one of the recommendations from the 1995 IOM report that urged us to improve the relationship between the university and the dental schools.

Forty-eight of our deans and 42 senior university administrators attended the meeting. There was a real appreciation for the paradigms that have to change within dental education, particularly in relation to the parent institutions.

We've undertaken four major initiatives since that meeting. One of them has to do with looking at the issue of "future faculty". We have nearly 300 available fully funded faculty positions. Remember, we can't talk about "clinical faculty" or "research faculty". There has to be that crossover. Hopefully dental schools will some day get to the point where scholarship in whatever form it takes – research or otherwise – is significantly valued and rewarded.

Half of our faculty are over 50 years of age. But when we surveyed graduating seniors last year, only 0.5 percent or 20 out of 4,000 graduate students indicated a desire to enter an academic career. We have been working very closely with NIDCR to look for the "two percent solution". If we can get to the point of moving from 0.5 percent to 2 percent of our graduating class, we would be able to address the faculty shortage that we face. The recent report of the Task Force on Future Dental School Faculty addresses some of these concerns.

The second area that we've been working on is the "cost of education". This is a complex problem. The reality is that students are graduating with combined college and dental school debt of $80,000 to $100,000 on average. This significantly affects the choices that they make and the kinds of careers they choose to pursue. The lure of private practice is very strong.

We are addressing the cost of education in a variety of ways. There are mechanisms in place that can be explored in terms of loan forgiveness, service in the National Service Corps, and so on.

A third initiative that we have introduced is our Leadership Institute. We have had a significant commitment from our dental schools to identify future leaders for careers in dental education, senior-level administration, and other roles within the academic health center in the university. We will again renew this Institute this year with 15 scholars who are among our "best and brightest" with a strong focus on mentoring.

Finally, one of the initiatives that emerged from the 1998 Summit was the development of a Center for Educational Policy and Research within AADS. This is an opportunity for us to bring together a variety of individuals who can advise us on some of the key issues that we are facing – issues like future faculty, cost of education, cultural competency, the role of scholarship, and the importance of scholarship within the university structure, as well as workforce issues.

In terms of our recommendations to the Blue Ribbon Panel, let me focus on just a few thematic areas. First is the financial issues that may create barriers. Look again at issues of training grants, salary caps, enhanced loan repayment programs, and so on. We acknowledge that we need to work on changing the culture within dental schools to some degree to value academic careers as an option for dental school students and residents. We have been discussing with NIDCR staff the possibility of organizing regional workshops on research opportunities, mentoring, identifying some people who have been very successful and working with them to understand the basis for their success.

Another thematic area is working on the "pipeline" or "shape of the river" issue. This includes forming collaborative efforts with AAMC and other health profession organizations at both the precollege and college levels. We strongly urge revisiting the issue of "midcareer development" to ensure that people remain flexible during their careers but also emphasizing the importance of mentoring. We must continue to ensure that there are opportunities for women and under-represented minorities in research.

We have a strong sense of urgency. We face 300 open positions. If we don't move forward quickly in addressing these issues, it may be too late to make the changes that we can make now.

Eli Schwarz, DDS, PhD[3]

Executive Director

American and International Associations for Dental Research

The American Association for Dental Research (AADR) is the largest nonprofit professional organization representing oral health scientists in the United States. It is the largest division of the International Association for Dental Research (IADR). The IADR and AADR missions focus on the promotion of dental research, support for the oral health research community and the transfer of scientific findings into practice.

Clearly the foundations of dental science have changed dramatically during the last decade of the 20th century. It is absolutely clear at this point that the focus for dental science includes post-genomic research, biomimetic and tissue engineering research, translational research, entirely

[3] Formal statement is available from the NIDCR Division of Extramural Research.

new clinical and epidemiological research, and strategic new research partnerships involving all parts of the dental care delivery system in the United States.

Research scientists trained to appreciate the problems of clinical dentistry should be prepared to apply the major scientific advances to solve the problems of dentistry. There are important opportunities in each of these areas for the basic scientists, translational scientists, and clinical scientist. The dentist of the future will require medical diagnostic skills and a superior understanding of oral biology so as to be able to screen for oral conditions that contribute to systemic disease and to prevent or treat oral and dental disease using the post-genomic technologies that will become available.

One issue that has bounced around involves clinical and epidemiological research. The foundations of clinical and epidemiological research now have entirely new meanings as we seek to apply these information gathering roles at all levels -- molecular, cellular, tissue, individual, and community. We are just beginning to hear the term "molecular epidemiologist." This science must be much better developed than it has been in the past, in order to test the application of sophisticated techniques to analyze disease and dysfunction states, as well as monitor intervention strategies.

The 21st century will also demand much stronger coordination of research efforts among all aspects of dental and craniofacial health care partners. Key players must insure efficient information exchange, continual opportunities for strategic partnerships, coordination that facilitates rapid reduction-to-practice of new health care ideas, and strong feedback to basic science from clinical application settings.

The training base for new scientists will certainly include foundational basic science. However, it also must include new skills such as the following ones. To paraphrase a popular term (e-commerce), the new science must take full advantage of "e-research."

Future leadership positions in the modern dental, craniofacial and oral health science programs must include dental-scientists with much more sophisticated management training. Leaders will need to have a much better understanding of the wide-ranging talents required to orchestrate new research teams. Cross training (especially in areas of translational research) will be necessary. Leaders must understand research management models and be capable of applying all the latest communication tools and computer sophistication to these models. Leaders must be able to coordinate the efforts of individuals who are more culturally diverse and more remotely located. The new research teams have been described as "virtual research groups." We will no longer be operating research like-minded teams that occupy the same lab at the same time.

Scientific leaders of the future will need to be able to manage large databases of research information. All research has now leaped into the realm of mega-data. The future model is not one of a hand-written laboratory experiment in a notebook in a single lab. The future model includes multiple investigator input, expansive computer data, and continual updating of local data into sophisticated databases that are foundations for scientific modeling experiments. Leaders must have a strong understanding of the systems required to operate research at these levels.

The clinical research scientists of the future should be trained in molecular biology and be able to apply new technology as clinical research methods. They should understand techniques for pooling/analysis of data across major clinical research centers. At this moment in time, we are finally beginning to expand opportunities for clinical research. However, despite these changes, clinical investigations have not yet embraced all the nano-molecular tools and techniques for monitoring clinical changes in patients.

Investigators must be trained in new research analysis methods such as fractal analysis, chaos theory, and computational biology to solve multi-dimensional problems. Investigators must be aware of the advanced nanoscale techniques (e.g. nanoscale-AFM imaging and property measurement, nanoscale-TEM, etc.) that are available for structure-function investigations.

With the recent explosion in scientific knowledge it is difficult, at best, for a scientist to become sufficiently expert in all aspects of the many disciplines involved in dental and oral health research. Rather, scientists of the future must be sufficiently educated in related disciplines so as to work as part of a multidisciplinary team. A research team would logically include basic scientists, dentists, and individuals with key "cross-training."

All of this new knowledge has begun to alter the traditional research training landscape. The role of faculty, departmental-based training environments, local research laboratories, and university homes for training may not be the correct infrastructure for producing new scientists. The competencies and skills that the new scientists will require are only occasionally found in traditional training systems. Therefore, we must look at ways to disseminate new information and skills using "distance learning and online learning techniques" in order to broaden access to the few teachers and curricula providing this training.

"Virtual laboratories" are possible using special online collaborations of teachers but this will require much better communication than currently exists in our traditional systems. Most universities and corporations have neither the infrastructure nor security that is necessary for advanced communications -- special telephone lines, online research confidentiality agreements, online research notebooks, special computer firewalls, and advanced encryption systems.

Clearly, training must also include re-training for the existing dental and craniofacial research community. While we are creating a new pipeline of individuals for future research, we must convert the existing human resource to a contemporary one that is competitive on all fronts. NIDCR and AADR both have major roles to play here. They must devise electronic portals for the current scientists that allow virtual sabbaticals, electronic workshops, and online mentoring systems to promote rapid re-training for existing scientists.

Superimposed on the changes is the fact that the supply of new scientists in dental and craniofacial research is dwindling. Various reasons have been promulgated for this trend, including the impact of education training debts, competing salaries of other professions, and poorly advertised opportunity in dental research.

In conclusion, I would like to comment from an international perspective. We tried to find out whether other parts of the world have experienced a lack of scientists in dentistry and oral health research. We were informed that the European Community has just conducted a survey that will be available around New Year. From anecdotal information we believe that the problems we see in the United States are being replicated in Europe. Europe, is however, comprised of many different countries. The solutions -- the levels of action -- will be very different in the European Community. However, the impact of the situation in Europe or elsewhere on the present perception of a growing shortage of qualified oral health researchers in the USA may be that the traditional brain drain towards the USA will not be available. Thus, there is an added impetus to solve the workforce-training problem in our research field as soon as possible.

Freeman A. Hrabowski, III, PhD

President

University of Maryland at Baltimore County

I am delighted to be here today. I would like to begin by describing our campus at the University of Maryland, Baltimore County. The campus is heavily focused on science and engineering. We have about 10,000 students; about 60 percent major in one of those areas. We produce about 60 PhDs each year, primarily in chemistry, biochemistry, other biology areas, engineering, and information technology.

There are many exciting prospects at the interface of chemistry, biology and genomics. Recent advances in genetics and protein chemistry will allow both chemists and biologists to attack disease on a very broad front, using methods of unheralded sophistication.

Currently, there is much buzz about the prospect of structural genomics, taking the human genome and determining structures of as many proteins encoded by the genome as quickly as possible. In the next 10 years, an important challenge facing chemists and biologists will be to characterize these protein targets in order to provide a basis for drugs of the future. It will be extremely important to establish genomic centers that focus on developing new, user-friendly tools for analyzing the genome and making predictions about which sequences may be important.

Major structural insights will probably be made by independent structural biologists who first know how to interact with the genomics database and then develop new methods for modifying proteins.

I spend about 20 percent of my time in science labs. I do this for two reasons. One of my primary responsibilities is to raise funds for the University. Therefore, it is very important that I am in constant communication with faculty about what they do. Secondly, I am very interested in understanding the connection between the research that we are doing and how we are going to spend the money as we get it and how well we are preparing our students.

On the campus, our chemists and biochemists are particularly well positioned to face these challenges, given our strengths in structural biochemistry, enzymology, synthetic and organic chemistry, and bioorganic chemistry. The structural biochemistry aspect is led, for example, by Michael Summers, whose determination of a variety of AIDS-related proteins has enormous implications in the fight against this disease. The Summers Lab uses sophisticated NMR techniques and computational methods to address fundamental issues of protein structure and function and macromolecular interactions. UMBC’s established NMR program continues to develop tools for the structural characterization of difficult proteins. In fact, of the three intact HIV proteins solved to date, two were solved first by the Summers Lab. What we now wish to do as a part of our future building efforts is to establish a genomic center where the faculty will include mathematicians, computer specialists, and computational biologists who will focus on developing tools for analyzing the enormous human genome database.

Further, it is not simply the structures of the molecules that are important, but also the potential ability to modify newly found molecules to provide therapeutic advantages.

In this regard, another one of our chemists is investigating the glyoxalase pathway in connection with a novel anti-cancer strategy. Another uses synthetic organic chemistry to develop nucleic acid analogs that have shown a variety of antiviral activities. This same laboratory uses sophisticated computer modeling to design modified hemoglobin that can potentially serve as substitutes for whole blood during emergency transfusions.

One of the most exciting challenges facing the biologists, chemists, and biochemists on our campus, then, will be enhanced interdisciplinary integration of information. We will benefit from connecting the molecular biology to structured determination of key macromolecules, to the genomic information, to the evolution of multigene systems, to molecular cytology, and the correlation of gene expression studied with gene array and protein technologies. Our success may depend not only on forging new collaborations within the campus but also among other campuses and others around the country. These are some general thoughts about where we are going on campus.

The Meyerhoff Scholars Program resulted from a major problem that we faced on our campus when I first joined UMBC about 12 years ago. The problem was this: While 60 percent of our students were entering the university with an interest in science and engineering of all types, only white and Asian students were succeeding in science. The African Americans and the Hispanics were not succeeding in science. We decided that we needed a special initiative to change the situation. That was in 1989.

according to the National Science Foundation, one of the leading producers of African Americans who go on for science PhDs in the country. This year we will have about 60 students from the Meyerhoff Program who are entering PhD or MD-PhD programs.

The emphasis of the Meyerhoff Scholars Program has been on producing PhDs. The first half million dollars for the program came from Robert Meyerhoff, a philanthropist in the Baltimore area. Much of the funding beyond the private funding has come from both NIH (MARC) and NSF (Alliance for Minority Participation).

The program's basic premise is that most of the money we have spent in this country for producing minority education has been spent on remediation. When we think about remediation, we think about minorities, we think about Blacks and Hispanics. When we think about high-achieving minorities, we think about Asians. This is just the reality.

Very little money has been spent on high-achieving African Americans and Hispanics. The assumption is that those students will be okay.

So the question was: How do we go about increasing the numbers of African Americans and Hispanics who will succeed in science?

I am aware that there is a need for more physicians and more dentists and other health professionals. What I say to dental schools and medical schools is this: "No one is giving me money to produce those students." We have focused on producing PhDs. The reason our program focused first and foremost on the PhD is that the money we got from NIH and NSF was specifically provided for that purpose.

What do our results show? Between 55 and 60 percent of our students go for the PhD or MD/PhD.

On most campuses, if a student is succeeding in science, people will tend to say: "Well, if this is a minority kid and he or she wants to be a dentist or a doctor, that's a great success." Well, it's true that it's a great success, but it is not meeting the objective of preparing more people to go into academic careers or to become researchers. So when students come to me and say, "I've decided to go to medical school and I'm going into the MD program at Harvard", they know I would say, "Oh, that's good." But it is not the same as if they had said they were going for a PhD or an MD/PhD.

Some people think this is a bit extreme, but it's the only way to change a pattern of successful minority students who almost never go into PhD programs or MD/PhD programs or DDS/PhD programs.

Now, that's on one side. And the other side is this: There has to be that excitement about science itself. So let me describe some of the components we use. I start with the fact that I make no apologies about looking for the very best students. We now get well over 2,000 applications for 40 slots per year. I could take many more if I had more money, quite frankly. But the fact is that we invite about 150 students over two weekends for intensive interviews and testing. We look for a number of factors, characteristics beyond test scores and grades – although test scores count very heavily.

In the meantime what we've done is to evaluate the outcomes of the students who attend our program versus those who decline our invitation and go instead to some of the best places in the country. We've studied these trends over the past eight years.

How have we been able to do that? There is such a good feeling when students visit our campus with their families – and we invite families to come and be a part of this experience – that they give us permission to look at their grades and their performance, even if they don't attend our university. So, we have been able to get the transcripts of students at other places. All of these are students in the top five percent among African Americans, if not the top one percent, and the top five to ten percent among all Americans. You're talking about an average SAT score for these students somewhere in the 1300's with many having near perfect math scores and a GPA of 3.7 or 3.8.

To try to understand what happens to our "Meyerhoff's" in other places, we ask the question, "Do they make it any way?"

Our results show that nine out of 10 students in the Meyerhoff program succeed in science. We define "success" as staying in science and having a GPA above 3.0.

What we find is that more than nine out of 10 students actually succeed by that definition compared with under half who remain in science at other institutions. Of that group, only about half who remain in science at other institutions graduate with an average above 3.0.

What do we do in the Meyerhoff program that is making a difference? We have a comprehensive set of components. We start with the idea of recruiting the top math and science kids.

Secondly, our special summer bridge program allows these students to work in study groups. This gives them an opportunity to see how university professors test in math and science. It takes them time to get accustomed to never seeing a minority faculty member. Most of the people they will meet in the laboratory do not look like them.

Scholarship support is contingent upon performance. We want them focused on academic work completely and not working on the outside.

There is heavy involvement of faculty. Our faculty are active research people well funded by NIH and NSF. These are the same people who work with students in the laboratories. In fact, Mike Summers, one of our faculty members and a Howard Hughes investigator, is actually sending about nine African Americans this year to science PhD programs. He's got over 20 people in his laboratory. Every one of those students has published in a refereed journal.

We have active researchers connected with these students literally from their freshman year and certainly after the freshman year. These faculty work with them in laboratories, get to know them and give them a chance to feel their enthusiasm for science.

These students are in the laboratory at three and four in the morning. Mike says he gets in and they are there waiting for him; they're working. That's the idea.

We strongly believe that students need to live the science. They need to be in the laboratories and talking about science. On our campus you'll go into a group and they'll be laughing. You'll think they are laughing about the party the night before; in fact, they're talking about something that happened in the laboratory. We encourage that kind of environment among our students.

We've always had large numbers of whites and Asians who go on to PhD programs. But to have African Americans and some of our Hispanic students doing the same thing is what makes our program different.

On our campus it is really cool to be smart in science. It is a major problem in our country that so many minority students don't feel good about showing that they are smart. On our campus, quite frankly, the number one sports competition is chess. We are national champions in chess, and we've got African Americans on the chess team. We're very proud of that. It's that kind of environment that makes the difference.

I've gone around the country and I've looked in classrooms in the best universities. I often see the African American students sitting in the back of the class, still looking "cool" just as they did in high school.

We tell our students to sit up front, get to know the faculty as soon as possible. Let them know that you're there to earn an A and that you want to learn as much as possible.

Study groups focus on understanding what is going well and what's not going as well. They focus on the work, understanding that you come to a study group only after you've done all the work you can possible do. Most of these students also serve as tutors to others on campus as well as for each other.

Then we provide personal advising and counseling – a mentor for every student on the campus. In addition to a faculty advisor but we also provide a minority mentor who may be a scientist or a physician, somebody in the health professions who can be supportive.

We also involve families. Whether the student is from New York or Baltimore, there is the need sometimes for special support. In fact, what we have found is that the brighter the child, the more emotional the problems. Probably the most difficult group I have to deal with are young black males with perfect math scores. There are so many emotional issues they're dealing with; we assume they are okay and they are not.

Overall, the fact is that we are giving these students a lot of attention. The program is still relatively small. We have 200 in the program right now. The model works. I know it works because the students are now in PhD programs; some have entered the dissertation level. Every student who has gone through medical school has finished.

Our challenge right now is to keep the momentum going and to document what works. One of the challenges we face in this country is paying attention to evaluation that can stand up in anybody's eyes. That's what we're working to do in our documentation and analysis of "best

Sylvia A. Frazier-Bowers, DDS, PhD

Dentist Scientist Award Appointee

University of North Carolina at Chapel Hill

Before I comment on the skills and training best suited for a clinician-scientist of the 21st century, I will briefly introduce myself. I am currently at the end of my Dentist Scientist Award (DSA) training at the University of North Carolina at Chapel Hill. I completed the clinical component of my training in orthodontics in May 1997. I am in the final stages of completing my Ph.D. thesis in Genetics and Molecular Biology. I thought it would be of interest to the panel to know a bit about my background prior to the beginning of the DSA program. My research career began during my last year of high school when I was awarded a summer fellowship from the National Academy of Applied Sciences. Although my goal at that point was to become a health professional, I had a strong desire to learn about science through hands-on research. I continued to participate in summer research fellowships throughout college. And, several years later, during my first year in Dental school, I was compelled to maintain my research involvement through participation in a clinical research project sponsored by the NIDCR. It was during the summer of my second year of dental school that I was selected to do a summer research fellowship in the bone research branch at the NIDCR. After a stimulating and exciting experience at the NIDCR, I made a commitment to a career as an academician.

In my application for the DSA program I wrote that my career objective was "to combine clinical

have the potential to greatly influence the practice of the dental clinician." Seven years later, neither my career goal nor my motivation has changed. Simply stated, my career goal is to become an academician who uses molecular research tools to answer clinical questions, while maintaining clinical and teaching activities. It is my belief that in order to accomplish this translational research one must remain active in clinical activities. It is this interface between the research and the clinical communities that affords the clinician-scientist the unique ability to ask scientific questions driven by clinical experiences and translate scientific data into clinically relevant standards.

The challenge I have recently encountered is identifying a path that will ultimately lead to a successful career. I now realize that the goal of the DSA program, to create a clinical scientist, is truly challenging. A solution to this challenge for future trainees may be to direct the prospective DSA trainees to institutions where they have access to Ph.D. projects that are within a terminal area of interest for them. This eliminates the necessity to endure another extensive training period after finishing their Ph.D. In other words, I have gained excellent training in two separate disciplines BUT not in an integrated training as the title "Dentist Scientist Award" suggests. This is because I did not have access to a research project that is biomedical or translational in nature. And, because neither translational research projects nor dual-trained mentors are readily available at many institutions. The problem that this poses is two-fold, namely one of efficiency and interest. Although the traditional Ph.D. student does several years of postdoctoral training, this plan is not efficient to train a clinician-scientist to perform translational research because it allows them to integrate readily into the dental academic community where they are needed. Moreover, the interest level of the dual-trained faculty member, and the clinical department to which they belong will be high. Because many clinician-scientists would like to maintain both clinical and research activities, the end product of this approach is a much smoother and more successful academic career. I am speaking not only from personal experience but also based on the experiences of two other Orthodontic-trained DSA's who consequently are not in academics any longer. These individuals also had Ph.D. projects that were not related to their clinical specialty. What ultimately happened in both situations is that their academic roles became too demanding this leading to their resigning. So, in summary, it appears that many institutions possess the ability to train scientists and clinicians, but rarely train "clinician-scientists." Moreover, their clinical department does not always utilize even a well-trained clinician-scientist properly.

By virtue of the fact that most institutions train (DSA) individuals successfully in two separate disciplines, it would follow that the skills necessary to be a scientist of the future are imparted during the training. And, most individuals who participate in a clinician-scientist-training program are being exposed to the same caliber of research as their "Ph.D.- only" cohorts. In either case, one of the most important competencies that these scientists must possess in order to be most successful is the ability to generate ideas. It is this ability that will allow scientists of the future to respond to the recent progress made in the area of Bioinformatics and due to the Human Genome project. Although future scientists will still be active at the "bench," there will be a shift in how scientific data is gathered. This will require that the competitive scientists know how to utilize and interpret results of computational analysis programs available today. Most graduate programs in the sciences currently require coursework and research training in molecular biology. One addition that could be made to current training programs is that training in Bioinformatics is required. This is not to suggest that technical skills are unnecessary, but that they must be enhanced with the ability to generate ideas and analyze the information available through various sources. In today's research community, it is not uncommon to pay someone to create a "knock-out" mouse, sequence DNA, and a variety of other services. There will also be a shift toward understanding how proteins function since the sequence of many genomes is readily available. Finally, the crucial element needed to create the confidence and success of a dual-trained individual is a very structured and customized training period that includes an appropriate mentor. This will ensure that the trainee not only get training as a clinician-scientist, but also receives counseling and advice in how to plan their career.

In summary, there is a definite need for the clinician-scientist in the 21st century. Training programs that intend to fulfill this need should focus on identifying where appropriate training environments with good mentors exist. Qualified individuals will be attracted to programs that have a proven track record of producing individuals who create an interface between the clinical and scientific communities. This is in sharp contrast to situations where individuals are asked to perform two separate job functions successfully. Often, this will lead to an unsatisfying career and ultimately "burn-out." Most institutions today offer the majority of what is needed to produce a well-trained scientist. It is therefore imperative that the respective departments, department chairs, senior faculty and mentors have the same understanding of how to produce a successful clinician-scientist. It is this cooperative effort between the clinical and scientific departments that will ensure that all parties (including the trainee) have the same vision, and thus achieve a common goal.

Jeanne M. Nervina

Dental Scientist Training Program Trainee

University of Connecticut School of Dental Medicine

My path through dental school is matched in its unorthodoxy by my path to dental school. While my Bachelor of Sciences degree in zoology and my Master of Science degree in zoology and physiology from the University of Wyoming are not altogether unusual, there are few dental students who have a working knowledge of the role of the eyes and the pineal gland in controlling plasma melatonin titers in rainbow trout. I am one of those few and consider myself lucky to have been advised by Dr. William A. Gern while conducting my master's research on pineal physiology. Dr. Gern instilled the solid foundation in basic research paradigms and philosophies that started me on my path toward becoming a research scientist. I followed this path to the University of Connecticut (UConn) School of Dental Medicine, where I am currently a seventh year DMD-PhD candidate and will be the first UConn student to complete the NIDCR's Dental Scientist Training Program (DSTP) fellowship. My doctorate will be awarded in biomedical science with an area of concentration in developmental biology.

By virtue of being a combined degree student, I have had the great good fortune of interacting with a number of brilliant faculty members and students not only in the UConn School of Dental Medicine, but also in the Graduate School and in the Medical School. The two faculty members who have had the greatest impact on my training are Dr. Alan G. Lurie, our Dental Scientist Training Program director, and Dr. Barbara E. Kream, from the Endocrinology Division of the Department of Medicine. Dr. Lurie's vision for the Dental Scientist Training Program is shaped by his years of research experience and a deep appreciation of the training requirements needed by future dental scientists. I have benefited directly from his untiring effort to establish a challenging and rewarding curriculum for the DMD-PhD students at UConn. Dr. Kream served as advisor during my dissertation research on inducible cAMP early repressor (ICER) expression in parathyroid hormone-treated osteoblasts. I have a profound admiration for Dr. Kream because of her unshakable integrity, remarkable intelligence, and deep commitment to science, not only as a researcher, but also as a mentor. Through her guidance, I developed a sense of independence as a scientist and I learned the two most important skills any researcher can have - how to ask the right question and how to pursue it.

Thus, with a solidly paved road behind me, I am prepared to finish traveling the path to a life in academic dentistry. To complete my training, I plan to specialize in orthodontics and to conduct postdoctoral research. Unfortunately, this final training phase will prove to be cumbersome, as there are no funding programs that allow both postgraduate curricula to be conducted simultaneously. All available federally funded postdoctoral fellowships require a percentage of dedicated research time that makes concurrent specialty training impossible. Therefore, if I want to compete for a postdoctoral fellowship, I must choose whether to do my specialty training first, followed by my postdoctoral training, or vice versa. Neither choice is particularly appealing, as both require time away from one of the disciplines - time during which valuable skills are quickly lost. Furthermore, unlike medical residents, many dental residents must pay tuition for their specialty training, thus incurring a major financial burden. In short, while the DSTP fellowship provides a tremendous mechanism for the initial training of dental scientists, the lack of a suitable postdoctoral fellowship still makes the path to a career in dental science inefficient and costly.

Ideally, DSTP graduates should have available to them a combined specialty-postdoctoral fellowship in which the time allotment for each discipline is established by the residency program. Fortunately, we need not look far for a model upon which to base such a fellowship. The NIDCR, through several recipient dental schools, presently offers the Dental Scientist Award (DSA) to outstanding candidates who pursue their dental specialty and doctoral training concurrently. Substituting postdoctoral research into the DSA paradigm would create an attractive program for DSTP graduates who look to obtain dental specialty training and, at the same time, acquire valuable training to become independent researchers.

The convening of this Blue Ribbon Panel would suggest that the deficits in adequate dental scientist programs, and their consequences, are not trivial issues. There simply are not enough dental scientists to fulfill the growing demand for new clinical protocols based on solid research.

Nor are there enough students choosing a life in dental science, because the greater appeal is to enter a private practice where income and stress levels out-compete those in academia. If we are to reverse this trend, we must make the training process and subsequent lifestyle as attractive as possible.

And, the sooner this is done the better. We are on the verge of a revolution in biology and a paradigm shift in dental clinical practice. The complete sequence of the human and mouse genomes will soon be available to researchers, bringing to reality technological and biological advances such as novel methods of gene transfer and gene targeting, new biomaterials, and biomimetics that were not even in our imagination a few years ago. We need more dental scientists to take advantage of this new information and to develop more sophisticated, biologically relevant, and efficient protocols to fight disease. But, this process will be far too big for molecular biologists to handle alone. It will require the input of physicists to delineate the role of biomechanical forces on cells and tissues, chemists to examine the dynamics of ion fluxes and protein chemistry in biological systems, biomaterials researchers to describe the interactions between nonbiological substances and biological issues, and computer programmers to generate algorithms that accurately model cellular responses to stimuli, just to name a few. There are no valid reasons why dental scientists cannot and should not fill any of these roles and in the process establish the multidisciplinary approach required to effectively study disease. Indeed, the dental scientist of the near future must be prepared to be a part of a highly integrated team that will study the genome and cellular physiology for what they really are - complex systems.

Through the course of my DSTP training, I have come to appreciate the expanding role of the dental scientist in both the research and the clinical settings, and where I fit into those settings. Interestingly, many people do not share my appreciation, as I am often asked why I chose such a non-traditional approach to dental practice, especially one that involves such intense, time consuming, and intellectually demanding training. The answer is simple, if not entirely satisfying. I want to practice academic dentistry because it is the only way that I know to affect real change in dentistry. As clinicians, we provide little in the way of curative dental care. Virtually every dental procedure has a failure rate and not all patients are candidates for all possible treatments, often leaving them with extraction as their only option. This is unacceptable. My training through the DSTP award has taught me to view disease at the molecular level and to consider treatment modalities aimed directly at the molecular mechanisms of the disease. Thus my goal as a dental scientist is to provide treatment from within the body instead of by patching up the outside as we do now. We are not far from this technology and I plan to be a part of the group that helps develop it. Thanks to the NIDCR's vision and their implementation of the Dental Scientist Training Program, I have a great chance to realize this goal.

Peg Nopoulos, MD

Mentored Patient-Oriented Research Career Development Awardee

University of Iowa Hospital, Iowa City

I am a 1989 graduate of the University of Iowa College of Medicine in Iowa City, Iowa. During my third and fourth years of medical school, I became very interested in psychiatry, and in particular the study of brain biology. I became involved in the Mental Health Clinical Research Center (MHCRC) and was fascinated by both the illness it studied (schizophrenia), as well as the potential it held for the study of the normal brain using state of the art neuroimaging techniques. After medical school, I entered a psychiatric residency at the University of Iowa.

Concomitant with the fourth year of residency, I began a fellowship in the neurobiology of schizophrenia (through the MHCRC) in 1992. Initially, my interests were in two areas: (1) the neurodevelopmental aspects of schizophrenia and (2) sex differences in the normal and diseased brain. Both of these areas of interest let me to pursue further the study of abnormal brain development.

After completing a two-year fellowship in the MHCRC, I accepted a faculty position (assistant professor) in the department of Psychiatry at the University of Iowa in July of 1994. I continued MRI work in schizophrenia and began to notice a triad of "themes:" (1) developmental brain anomalies (especially midline), (2) cognitive deficits (which are quite significant in schizophrenia), and (3) craniofacial anomalies (minor physical anomalies being common in schizophrenia with high steepled palate being the most frequent finding). The findings in this "triad" in schizophrenia are quite subtle (especially craniofacial anomalies), so I searched for another venue to study these relationships. I began to learn more about craniofacial anomalies and in particular cleft lip and palate. After learning more about the cognitive deficits seen in these patients, and the relationships between brain and face development, I identified brain/behavior relationships in clefting disorders and/or craniofacial syndromes to be an important area of research and one that I was keenly interested in pursuing. I began to search the literature for studies investigating the relationship between brain structure and function in clefting syndromes. To my astonishment, there were none! This, of course, fueled my enthusiasm even further.

In parallel with the advances in neuroimaging, the field of human genetics has simply exploded over the last decade. In particular, the genetics of cleft lip and palate have been very generative. At the University of Iowa we have two internationally renown centers: (1) The Mental Health Clinical Research Center, in which state of the art brain imaging is done, and (2) the Craniofacial Anomalies Research Center (CARC), conducting cutting edge genetics research. This presents a unique opportunity to study, in a meaningful way, the relationship between the genetic determinants of facial clefts and brain structure/function. This opportunity is the focus of my Mentored Patient Oriented Research Career Development Award (K23), which was recently funded in April of 1999. While I have training in structural imaging of the brain, I feel that I require additional training in developmental biology, cognitive assessment, clinical assessment of genetic syndromes, and molecular and quantitative genetics. This training will be integrated with a research project in which I propose to phenotype Van der Woude Syndrome (VDWS), an autosomal dominant disorder manifesting as isolated clefts of the lip and/or palate and lip pits, by: (1) evaluating brain structure of patients using Magnetic Resonance Imaging, and (2) evaluating brain function in these patients using neuropsychological tests. In addition, these patients with VDWS will be screened for micro-deletions using an allele loss assay. This will allow direct phenotype/genotype correlations to explore the relationship between the genetic determinants of facial clefting and brain structure/function. These findings will lead to a better understanding of the neurobiology underlying the cognitive dysfunction that significantly impairs the life of many patients with facial clefts. In turn, these findings may lead to early intervention with detection and treatment of cognitive deficits.

What do I believe are the most promising research opportunities in the 21st century?

At the risk of sounding biased to my own area of research, I believe one of the most promising and one of the most important research opportunities for craniofacial disorders is the study of the relationship between development of the face and brain. Facial clefts are frequently associated with cognitive dysfunction. In syndromic clefting disorders, cognitive dysfunction is ubiquitous and often severe. In isolated or non-syndromic clefting, the cognitive dysfunction is not as severe, but quite prominent. In fact, impairment of intellectual abilities is often much more morbid than the craniofacial defect. For instance, correcting and adapting to a cleft palate are difficult indeed, but may pale in comparison to the morbidity of mental dysfunction - learning disability, mental retardation, overall poor level of function or even the need for institutionalization.

The fact that clefts of the lip and palate are associated with brain abnormalities should not be a surprise as the development of the brain and face is intimately related. However, the systematic study of the types of brain anomalies present in the patients with clefts of the lip and palate (and the functional consequences thereof) has been almost completely overlooked. The importance of understanding the relationship between brain abnormalities and craniofacial defects cannot be underestimated. Learning more about how the brain is affected in those with cleft lip and palate can potentially inform many different aspects of facial clefting research and treatment.

If there are indeed brain abnormalities associated with facial clefting, understanding who they occur in and how it is manifested will no doubt inform the prognosis of these patients. Future studies using functional tools to evaluate brain function (such as PET or functional MRI) may help in defining those children who may benefit from certain types of corrective surgery.

A better understanding of the relationship between cognitive dysfunction and brain dysfunction will most certainly advance the understanding of the neurobiological basis of cognitive dysfunction. This will be applicable not only to patients with cleft lip and palate, but also other developmental syndromes that manifest cognitive deficits.

The etiology of facial clefting is unknown. There is clearly a strong genetic component. However, non-syndromic facial clefts are a very heterogeneous group of patients. The study of brain structure and function in this group may help to better "phenotype" or identify subgroups of patients that are more homogeneous in etiology. In this manner, phenotyping may help to inform the study of the genetic determinants of facial clefting.

What skills or competencies do I feel future research scientists must acquire in order to respond to those opportunities?

I am a physician-scientist (M.D. only, no Ph.D.), and therefore discussion of this question will be answered from this perspective.

The training of a physician is, of course, heavily clinically oriented. During medical school, very little emphasis is placed on the basics of becoming a scientist although there is some exposure to classes such as biostatistics. In residency, the physician is trained further in clinical skills. It is only after completing residency that a physician interested in scientific work can get training in research methods, usually through the mechanism of a fellowship. The physician brings to research the advantage of their clinical training - a level of understanding of disease illness/ medical condition, that is unparalleled by any other type of exposure to patients. The physician knows and learns the illness/ condition by treating the human. However, research from this perspective only (clinical) is still limited.

On the other side of the coin is medical research from the basic science perspective. The study of an illness/ condition informed by research fields such as physiology or molecular genetics provides an insight into disease pathology at the level in which discovery of etiology and pathophysiology is truly within reach. Yet without a clinical frame of reference, basic science can also be quite limited and restrictive.

The true marriage of basic and clinical research provides the best opportunity for scientific success and discovery. One possible way for this to be done is for "collaboration" between the clinical researcher and the basic researcher. The mutual training and education of the respective scientists in the field of their collaborator can facilitate this relationship. For example, the training and education of the physician in an area of basic science research that is relevant to his/her clinical field. Great strides have been made in both the clinical and basic science domains in the past few decades. However, the gap between them still remains quite wide. The training of clinicians in the basic sciences relevant to their work is one of the best ways to prepare that clinician to be a successful research scientist of the future.

Paul C. Dechow, PhD[4]

Director, NRSA Institutional Training Program

Baylor College of Dentistry

My name is Paul Dechow. I have a PhD from the University of Chicago in anatomy and evolutionary biology. My research is in bone biology and functional anthropology, using the face as a model system. It was during my postdoctoral training at the University of Michigan that I became involved in dental education. After joining the faculty at the Baylor College of Dentistry in Dallas in the late 1980's, I became the director of a PhD program, which has grown tremendously in the past five years.

One of the unusual features of the Baylor College of Dentistry is that we have our own basic science department that is also dedicated to doing research in areas of interest to academic and clinical dentistry. This allows faculty with combined degrees to work in the basic science department as well as in one of our clinical science departments.

In preparing my talk today, I polled the directors of NRSA postdoctoral programs receiving support from NIDCR. I posed the six following questions:

- Given the complexity and breadth of the scientific opportunities, what specific models for research training and career development should be considered? Are there unique models for different types of research (basic, behavioral, clinical)?
- What are the basic components for the design, implementation and evaluation of national training and research career development programs?
- What partnerships and collaborations, such as with private industry and foundations, are possible to enhance future research training and career development efforts?
- How can we approach recruitment and retention of individuals and multidisciplinary teams to research?
- How can a strong mentoring system be established for individuals and interdisciplinary research teams?
- How can the NIDCR intramural research program become more involved in the research career development effort, both as a provider of basic and clinical research training as well as the recipient of outstanding new basic scientists and clinical investigators? How can we maximize extramural-intramural partnerships for future training?

There are 36 NRSA postdoctoral training programs around the country supported by NIDCR. These programs have about 139 trainees, which represent the largest group of trainees funded by NIDCR. Thirty-three of the 36 programs are based in dental schools. The programs are found at

[4] Formal statement is available from the NIDCR Division of Extramural Research.

18 institutions; 21 of the programs are located in just six schools. Most of the program directors hold research doctorates (PhDs), although about a third have combined DDS-PhD degrees.

In contrast to the rest of the National Institutes of Health, NIDCR funds a smaller percentage of postdoctoral trainees through individual fellowships than through institutional training grants. At the NIDCR about 1 out of 15 fellows has an individual award compared to about 2 out of 5 at all NIH institutes combined.

The NIDCR research training programs represent much of the future direction of dental research. Current NRSA training areas include the behavioral sciences, craniofacial biology, neuroscience, and the like. I have listed the number of postdoctoral NRSA training programs and institutional fellowships in a separate table (below)

Area	Programs	Fellows
Behavioral Sciences	1	4
Craniofacial Biology	4	15
Dental Materials	5	23
Epidemiology	7	29
Neuroscience	7	22
Oral Biology	12	46
Dental Informatics	3	?

The key competencies to advanced research in each of these areas will be the ability to apply growing and novel technologies to the large array of clinical problems and the basic sciences of modern dentistry and craniofacial health. It is important to ground the students well in their fields within dental research and clinical dentistry, as well as to provide the best exposure to those modern biomedical sciences that will advance the student's chosen research. Many program directors also feel that it is important to explore "survival skills" with students, including training in how to give talks, how to write, how to write grants, how to deal with ethical issues.

The NRSA grant, as we have used it at Baylor, has allowed us to provide opportunities for our students in these areas. We have used the NRSA funding to leverage further funding from the administration to provide individual grants of some sort for all of our students.

Of the 20 students we have in our program, a small number are postdoctoral trainees. The largest group is working towards a PhD specialty area. Since our basic science department is in one location, these students all interact. It doesn't matter where they are in their clinical careers, the one thing that binds them together is science – how it works and the real excitement of doing science.

In summary, the NRSA program has been very useful to us and others because of its flexibility for training researchers. However, this flexibility could be increased. For example, we should be able it to send students routinely to other institutes for short-term courses, or longer term if the circumstances dictate. The NRSA could also be made to be even more flexible; it would allow us to recruit students into research earlier in their clinical careers, such as during dental school. These are just a few suggestions; others can be found in my formal statement.

Mark C. Herzberg, DDS, PhD[5]

Director, Dentist Scientist Program

University of Minnesota School of Dentistry

I would like to talk about the Dentist Scientist Award (DSA) Program and NIDCR Research Training: Starting with a Clean Slate. If asked to start all over again, where would we go? What might we do? How would we deal with some of the issues that we know are out there?

In the last few weeks, we collected information from DSA program directors. We have received responses from seven of the 10 programs. We reviewed the current situation of those who entered the program between 1985 and 1996 and those who will be completing the program through this year.

Sixty-five people passed through these 7 programs. Forty-nine of the 65 people who completed their training have and are currently in fulltime academic positions, including postdoctoral training. Thirty-six have extramural funding. Thirty-three of the 65 have at least one NIH grant. Twenty-one have non-NIH grants and contracts. Some have both NIH and non-NIH support. Twenty-nine of the 65 have more than six peer-reviewed publications. So, clearly, this mix of people has sustained research activity. Some of the former trainees are working in private practice, two are working in biotech companies, and a couple are career military people.

the context of training. I like the definition offered by the distinguished Nobel Laureate, Albert Szent-Gyorgyi: "Research is to see what everybody else has seen, and to think what nobody else has thought." It implies a level of creativity incumbent to superior science that is very difficult to capture with courses, with specific qualities, with specific competencies.

Will dental and craniofacial research prosper in the year 2020 if dental school culture yields very few people to basic and translational research training and to research careers? Will dental and craniofacial research prosper 21 years from now if fundamental and translational research emphasis declines in dental schools to increase in medical schools? Will dental and craniofacial research prosper if the visibility of training opportunities declines from what it is now? How can we keep visibility high? How can we keep people informed? How can we be involved in K through 12, in colleges, in dental schools, in PhD programs, in medical schools so that people are aware that dental and craniofacial research and scientists are not only players, they are really leaders?

After we go through the exercise of proteomics, we will be able to create a physiologic synthesis of cells, tissues, organs, and organisms. In a sense, there will be a next generation of bioengineers. They will be molecular-based, using the machinery of the organism to recapitulate itself. There are also hot biological research areas. The odontogenic homeobox code is being deciphered so that we understand what makes tooth germs form and teeth form. Someday a restorative dentist will use molecular tools. We won't have to make crowns and bridges; we will apply a protein signal to the gingiva to get the birth of a new tooth.

The hot research areas are really hypotheses; they are questions in search of answers. What you would like is a program where hot questions are being asked and the programs can interface with the best technologies of the time to generate new fundamental facts using the strongest possible

[5] Formal statement is available from the NIDCR Division of Extramural Research.

paradigms. If we look at the education trajectory from kindergarten through college, professional education and private practice, we can make some changes. There are concepts and knowledge that relate to dental and craniofacial research that every kindergarten student in the United States knows. For example, there is a dentist; there is something called oral hygiene; they have a notion of what a toothbrush is and how to use it. As children grow older, they learn about orthodontics and they may have a concept of biomechanics. As they enter high school, they study biology, chemistry, and physics. Once they get into college, much of this information is repeated again. They are developing a more comprehensive approach to understanding things that relate to dental and craniofacial research. We are not capitalizing on this growth in knowledge.

In college, we've got to make better connections with pre-medical and pre-dental advisors. If a bright student goes to an advisor and says: "I'm interested in the pathology of human disease and I'm interested in craniofacial biology. I think I'd like to go to dental school and become a scientist." The advisor often says: "You've got a 3.8 GPA. You're a very bright person. Why don't you go into the MD-PhD program? Why bother with the dental thing?"

We would like to think that the dental schools, virtually all of which are at major research universities, would open up their doors and become great intellectual bastions where students can really become leaders in a whole variety of fields. We would like to think that dentists would also study neuroscience in some depth, molecular biology, developmental biology, genetics, biomechanics, topology, and economics. Interdisciplinary learning will stimulate creativity and empower the development of professional leaders. Furthermore, educational collaborations between dental schools and other schools of the university would provide the fertile learning environment that would attract the best and the brightest to train to investigate compelling problems in dental and craniofacial science.

A few final points: I think that institutional training programs should be awarded to what I will call "qualifying institutions". What I mean by that is that every institution needs an infrastructure so that they can reach out to a variety of constituency communities from which they can recruit. They have to be able to reach out to minority institutions and they need personnel associated with the program that share the programmatic goals and values.

The NIDCR needs a balanced portfolio that provides separate programs for basic research training, clinical research training, with multiple points of entry. There has to be diversity in the types and intellectual mix of scientists. And the programs have to be visible. I believe the lack of visibility is one of the major shortcomings of the NIDCR training programs, particularly if you compare the NIDCR programs with the MD-PhD programs available through the NIH.

SUMMARY

- Dental school/university academic culture
- Balanced portfolio
- Diversity
  - Types of scientists
  - Multiple points of entry
  - Scope of research
  - Intellectual mix
- Visibility

- Qualifying institution must provide best science/mentoring
- Separate programs for basic/translational and clinical research
- Seek trainees for PhD, postdocs, DDS, post-

  research training
- Basic investigations; technological development
- Recruit widely among institutions, majors, etc.
- Many programs and qualifying institutions (with critical mass); partner/collaborate to build unique strengths, not assimilate

Freddie L. Jordan, PhD[6]

Director, Short-Term Training Program

The Ohio State University College of Dentistry

My objective is to summarize the view of T35 "Short-Term Institutional Research Training Awards" program directors. To prepare for my presentation, I set up a survey on the Internet. I contacted T35 program directors and requested that they direct their students to the site to give us feedback.

Let me begin with some general statements about the T35 program.

The T35 mechanism fulfills a number of needs other than development of a pool of dental researchers. This three-month training experience provides an exposure to research but it cannot provide the average or even exceptional dental student with skills needed to work independently in a research field. Some students may come to the short-term training program, of course, with sufficient prior experience for the program to move them toward independent research. But this is not typical.

After a three-month exposure to research, some students will inevitably decide that they are not destined for a research career. It is probably best, from an economic point of view, that this happens early on before resources are invested in their development.

Thus, a brief exposure to research during the early dental school years seems a practical investment. However, for those students who do resonate with research, it is essential to extend their research experience to help them begin to develop their skills as independent scientists.

There are two ways to do this. First, they can begin their research training earlier -- that is, upon acceptance to dental school, or, as in our case, even *prior* to dental school. Students who come to Ohio State University and have expressed an interest in research and/or have previous research experience have an opportunity to start research work before entering dental school.

Second, highly interested, motivated, and competent students who have completed their first three months of research training, should be encouraged to continue their research into the clinical years. Funding for such a program under auspices of the short-term training grant is technically allowed. We have implemented just such a strategy at the Ohio State University. In fact, I got together with some of the department chairs and wrote a policy that permits students to work two-and-a-half days a week in the research laboratory while they are in the clinic.

For the T35 program to succeed, it must support the research experience of the students. Students really need an environment that fosters and supports research, not just for purposes of stipends or for purposes of specialty programs, but because it is interpolated into the fiber, fabric of the institution and schools. This goes back to curriculum reform. It goes back to the faculty on board. After the first one or two years of basic science, they just get so overwhelmed with clinical training because they are working alongside faculty who are not reinforcing the research experience. So, it is important to emphasize that it should be an intrinsic institutional response to foster opportunities to extend the research experience throughout the clinical years.

Perhaps the National Institute of Dental and Craniofacial Research could work together with the dental community to make these students feel more like junior colleagues and make them aware that they are in the "pipeline."

[6] Formal statement is available from the NIDCR Division of Extramural Research.

Even, the American Dental Association should be a partner. I cannot say too strongly that organized dentistry is a major culprit to the inertia that is in these dental schools. Possible options would include visits to or conferences at the NIH campus, meetings at the AADR, mailings from graduate program directors, newsletters, Ohio State/Michigan Due and Regions Ohio Valley Competition, et cetera.

Finally, an obvious practical reward for a dentist choosing to enter a research career would be debt relief. Perhaps this suggestion is beyond the charge of this Blue Ribbon panel, however.

Now, concerning the question: What are the scientific research opportunities in the 21st century? This is very difficult to answer. The majority of opportunities are in genomics, in the development of tissue structure and functional restoration, research in health services, including treatment outcomes, and the study of complex systems. However, we are having a hard time viewing a future for dentist scientists, given the background and affiliation of the awardees of the comprehensive centers. To our knowledge, no dental scientist serves as a principal investigator at any of the centers to be funded by NIDCR. Perhaps, this is an issue that should be addressed.

Given the above, the current message is, "Forget dentistry." Students should be trained for multi-disciplinary approaches to research. They should be encouraged to be team players. They should be well schooled in molecular and cellular biology and able to keep current with or at least utilize bioinformatics. They should be familiar with emerging imaging technologies. They should be better schooled in statistically based research design, particularly as pertaining to animal modeling and the use of human subjects. In addition, they should be better schooled or educated in the responsible conduct of research, mentoring, and able to manage ethical conflicts that frequently arise.

Now, regarding our Internet survey, we wanted student reactions to the following types of questions: Why are you doing research? Why are you making these choices? Why are you being recruited?

Basically, we posed three questions. The first one was, "I've chosen to participate in the summer research program because -- " and then we gave them several choices, ranging from financing their dental education to entering specialty degrees because they thought it was a vital part of their professional education, or to teach and do research or to solve clinical problems. The number one answer was that they felt that they were choosing to participate in research because they thought it was vital part of their professional education, followed by solving clinical problems in their practice, third being to finance their education, and, fourth, to enter a specialty program, and, finally, to teach and do research.

We asked, "What is the most important thing" that they hope to get from their research experience? The choices included: a means to get promoted and earn more money, increase opportunities for post-graduate work in their specialties, and understanding of how science is done. The number one response was they wanted to have a better understanding of how science is done; this is very important because it achieves the program’s goals. This response was followed by increasing the opportunities for post-graduate work, followed by going to the AADR meeting, and the final answer was only 20 percent saying that they thought it would be a good way to get promotion and earn money.

The third question we asked involved their future plans. We asked them: "Which of the following best characterizes your future 10-year-plus plans?" The choices were: hope to be in general practice, I will be a faculty member in a dental school, I hope to be in a specialty practice, or I wish to be a part of public health service or armed services.

The number one answer, " I hope to be in specialty practice." This was followed by " I hope to be in general practice." The third answer was they wanted to be a faculty member in a dental college.

Finally, we wanted to know, "Should dental students be required to learn the scientific method and the basic process of research?" About 82 percent said "yes".

"Should all professional students be required to do some form of research as part of their pre-doctoral education?" Twenty-seven percent said "yes," meaning approximately 70 percent said "no."

These findings validate the idea that students select pre-doctoral research programs mainly for goals that are directly and ultimately in preparation for specialty programs. However, while students agree that they should be required to understand the scientific method and the basic process of research, they disagree that some form of research experience should be required as part of their pre-doctoral education. (It should be noted that students not involved in research were not asked the same set of questions (control) and from a scientific point of view, defending the information gathered is difficult. Since 27 percent of the students doing research felt that all students should do research, it would be interesting to have asked non-research students the same question. Probably the answer would be less than 27 percent, but we don't know. However, it is our intent to follow-up on this point.)

In conclusion, I'd like to thank Dr. Sam Rosen at Ohio State University, Dr. Linda LeResche at the University of Washington, and Dr. Bruce Rutherford at the University of Michigan for their input.

Alan G. Lurie, DDS, PhD[7]

Director, Dental Scientist Training Program

University of Connecticut School of Dental Medicine

When people make the decision to become a scientist and academic dentist, there exists an array of programs that offer the potential dentist the opportunity to engage in an academic career. These include T32 awards, the DSA, and the DSTP. I think that it is important to maintain the diversity of these programs to assure the future advancement of research in dentistry. We have had – and have – all of these programs at the University of Connecticut. They all have a role in promoting a strong academic environment.

The DSTP at Connecticut, which is the combined DMD/PhD program, is now in the fourth year of its first cycle of funding from NIDCR. This program addresses a lot of the issues raised at this meeting of the Blue Ribbon Panel. First of all, it starts early. It is the earliest serious commitment to an academic career that is available to someone in dentistry. Before this program was formed, one could construct such a program on an individual basis but one's academic career decision was still made later after you became a dentist. It is both a strength and a weakness of the DSTP program to be making a decision at an earlier time – making the decision at a more immature stage of life versus focusing on an academic career sooner with a longer

[7] Formal statement is available from the NIDCR Division of Extramural Research.

career future. This early decision seems to be a desirable attribute in the minds of most participants.

This program immediately starts creating a “translator” – an individual able to comfortably bridge the clinical and laboratory sciences, and to operate and teach in both. Being a “translator” appears to be a very important aspect in the minds of most participants. The DSTP program, and its subsequent postdoctoral training with or without specialty training, is going to create a person who is going to be competent at translational research and at basic research. It will create a potential leader and a role model for dental schools throughout the country. DSTP trainees are individuals who will assume faculty positions. They will interact with students at all education levels. They will work with them in clinics. They will work with them in the laboratory. They will demonstrate first-hand that you can do both clinical and research activities, and that you can do them both well.

The DSTP graduate finishes training with essentially zero debt – compared to the average $130,000 of indebtedness of a DMD or DDS graduate. This is certainly an attractive aspect of the program. Recruitment is made treacherous by the need to identify individuals who would use the 7 years of federal funding to acquire a debt-free degree and then practice clinical dentistry full-time.

This DMD/PhD program is most effective when it is integrated with a medical school and with a broad basic biomedical science, population-based science and public health science curriculum. At Connecticut, we are fortunate to have all of these different aspects in place in a single building. I think that is a substantial contributor to our success in operating these training programs. There are not impenetrable walls between the medical and dental schools. There is a minimal second-class citizenship that is pretty easily dealt with if you just walk down the hall to one of your medical or research colleagues and start working with them. I have never personally experienced any discrimination on the basis of my degree in 26 years at the University.

How can the DSTP program be improved? It’s hard to respond directly because we are just producing our first program graduate. However, I have three specific recommendations one of which is the responsibility of NIDCR, and the other two of which are the responsibilities of the training institutions – and of dentistry at large.

First and foremost is the culture in the dental clinical sciences; the pervasive, negative attitude towards any dental career that is not clinical practice must change. This mindset of the dental clinics is a major impediment to a student who wants to become an academic dentist. Sometimes it is very quiet and covert, and sometimes it is very overt and destructive action. I have seen a clinical faculty member at a very enlightened academic institution make a ruthless and destructive remark to two students who were interested in a career in science: “Why are you wasting your time in the lab? It has nothing to do with being a dentist.” End of interest in science. This must stop. An attitudinal adjustment must occur internally within the schools, and such change to be supported by every aspect of organized dentistry and dental education.

Second, there needs to be the opportunity within all training programs for trainees to teach. They get training in science. They get their clinical training. Then they walk into a classroom with 80 people looking at them. Unless they have had many years of experience as a performing musician behind them, it can be a little difficult to face that situation and perform well.

There are opportunities for DSTP people to teach. For example, when they are into their PhD programs, they can certainly take part in seminars, case conferences and teaching programs within the basic science curriculum. In schools that have problem-based-learning (PBL) programs, a DSTP candidate and a DSA person are ideal facilitators for PBL groups. It would be helpful if some exposure to classroom teaching could be incorporated into their programs.

Finally, we need "infrastructural" money for this program. The DSTP award is a grant that does not allow SSOG costs. There is not support for administrative assistance in recruiting students or in operating the day-to-day business of running the grant. DSTP directors are spending 10 – 20 percent of their time on these programs and their trainees, and are doing so without any support for their time. They are working gratis, and this is not often looked upon favorably by dental school administrations. I would urge that a mechanism of administrative support for the DSTP programs be developed; perhaps a small supplemental NIDCR grant could be created that provides administrative support to operate these grants.

We can't assess the outcome of the DSTP program because there isn't any outcome yet. There are some people around the country with both the DMD and PhD degree, but they didn't earn them through the DSTP program. But when it comes to assessing outcome, I think it would be a serious mistake to look solely at being a Principal Investigator (PI) on an R01 grant. There is much more to academic dentistry and academic medicine than obtaining an R01 grant. Multidisciplinary research is the research method *dujour*, and only one person can be the PI. You need to look at their successes in collaborative research, teaching, directing graduate programs, training more scientists, developing new products for industry, and being leaders.

Just to recapitulate: What makes a good scientist? A good scientist is someone who reads the literature critically, who asks the perceptive question and has the training and the creativity to design the experiments to answer the question. It is someone who has the intellectual development to analyze the data, discuss the data, and communicate the information to colleagues and students. This is the person we hope to be training in the DSTP program, as well as in the DSA program.